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AN APPROACH TO ESTABLISHING THE CHARACTERISTICS OF A FLEXIBLE MODULAR LARGE-SCALE DETECTION SYSTEM FOR THE STUDY OF COMPLEX HIGH-ENERGY EVENTS

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The concept of the "hybrid" spectrometer was first set forth in paper A3-68-12, "A High-Accuracy, Large Solid-Angle Detector for Multiparticle Final States at 100 Gev/c", by Fields et al., very early in the course of the 1968 Summer Study. The subsequent evolution of that concept during the remainder of the summer is partially documented in a series of additional reports listed in Appendix I-A. The parallel concept of the 12-meter streamer chamber as an alternative system, based on what the Summer Study came to know as the YCDIBWASC theorem (You Can Do it Better With a Streamer Chamber) was also introduced, as were several experimental designs for particular high-energy experiments. These are listed in Appendix I-B.

Further development since the Summer Study has mainly consisted of the slow process of digesting these concepts. Since the process of digestion includes, in addition to simple combustion producing heat, a resynthesis of the components of the food into new complex organic structures, let us examine the results to date to see how far the digestion has gone, and whether TUMS (or stronger measures) are indicated. We note that there are two kinds of food contributing, although each comes in a wide variety of flavors, more or less appetising: the proposed multipurpose system, and the individual experimental design. (I manfully resist the temptation to pursue the digestive metaphor any further down the alimentary canal).

The synthesis at which we aim is the establishment of a tentative set of characteristics for a large-scale detector system. They are neither performance specifications nor design specifications, but a mixture of both. What follows is a status report on my own personal view of what should be expected from such a system.

PROPOSED CHARACTERISTICS

1. In a large class of experiments, it is important to know just what primary interaction has occurred. (The excluded class, in which it is not important to know, is also large). If one is to be able to make a kinematic fit good enough to tell whether or not a neutral pion has escaped detection, a definite set of performance requirements on momentum accuracy results. They are:

   a) Momentum accuracy of 0.1 Gev/c or better to highest energy measured.

   b) Transverse momentum accuracy to 20 Mev/c.

2. The most expensive part of the system is likely to be that magnet in which the highest momenta are measured; for 100 Gev/c and an assumed "setting error" of 0.2 mm, one arrives at Bl values like 150-200 kgauss-meters.

   For economy and flexibility, the system should therefore be modular, with at least two sections, low- and high-energy.

3. The size of the magnets, and indeed the scale of the entire system, depends critically, and about linearly, on the "setting error". Improving it a factor of two may cut the field requirement by about the same factor. Hence in system design, increase of accuracy holds a place of unique importance. (This is the "Lederman Theorem".)

4. For maximum economy, the particles of highest energy should be measured by observing total angle of deflection in a magnet rather than measuring the curvature in a field; the latter procedure leads to larger magnets. Because the small and constant average transverse momentum leads to narrow cones of emission, this procedure is eminently practical at high energies. This conclusion is independent of the level of accuracy desired.

5. One part of the system that has not yet settled down is the device for viewing the low-momentum particles from the target vertex; it contains the target. In the original proposal it is a fast-cycling bubble chamber. Hydrogen targets in conjunction with wide-gap spark chambers and streamer chambers have been considered as substitutes that give greater flexibility of targeting and triggering, and offer isotropic viewing. Their major disadvantage is the inability to see the interaction vertex itself in hydrogen. Since the evaluation of these relative advantages and disadvantages is experiment-dependent, one can only remark at this point that since the low-momentum region is the least expensive to analyze, this choice can be left open, or at least delayed.

6. The system must be so designed that neutral particle detectors can be included in it.

The desirable characteristics of the neutral particle detector could well be the subject of an independent study. In brief, they are

a) Sensitivity to both gamma-rays and neutrons, and the ability to distinguish between them.

b) Accurate location of the vertex where the neutral interacts with the detector; if the source of the neutral particle is known this established the line of flight, which is even more valuable than the energy in making kinematic fits.

c) Ability to observe the direction of the neutral particle, independent of information concerning its source. This is particularly important if the event studied has more than one vertex and ambiguity concerning the source of the neutral exists. In the case of gamma-ray-sensitive spark chambers this implies many gaps per radition length, and, therefore, large volume detectors.

Detection of neutrals implies the possibility of their escape from the target; thus chambers surrounding the target must not be black for neutrals.

7. One of the more important conclusions is an emphasis on the value of adequate triggering schemes. Absence of triggering methods will mean that little selection of events can be made, a condition more serious for very high energies than for energies presently available, if interest lies in a particular channel. The limited amount of triggering possible for bubble chambers is the principal reason for seeking other devices for viewing the target vertex. The best that can be done here is the adoption of rapid-cycling chambers with triggering selection on the lights, an approach that has proven reasonably fruitful at PPA. This requirement argues against any inflexible large single-section device, e.g., the large streamer chamber.

8. Selection of certain kinds of reactions may simplify the system considerably. An example is peripheral rho production, in which no complete kinematic fit is sought, but only assurance that a rho

has been produced. In particular the high-energy module may often be used independently.

9. Firm requirements for data readout cannot be written; but one can reaffirm the well-established importance of enough quick turn-around processing to be sure the experiment is working properly, and the even greater value of getting enough data analysis, soon enough that the results can be used to affect the subsequent course of the experiment.

10. If the system is designed to be composed of several components (e.g., a fast-cycling bubble chamber plus a wire-chamber spectrometer) the separate components should be designed to be able to be used independently if need be. As noted above, this is especially true of the high-energy spectrometer unit.

APPENDIX I

A. Papers on Hybrid Spectrometers

A.3-68-12	A High-Accuracy, Large Solid Angle Detector for Multiparticle Final States at 100 GeV
A.3-68-13	Further Studies on a Combined Bubble-Spark Chamber High-Accuracy Detection System for Multiparticle Final States at 100 GeV
A.3-68-33	Proposed Modification to Combined Bubble Chamber Plus Spark Chamber System
A.3-68-45	Comments on the Bubble Chamber Spark Chamber Detector Proposed by T. Fields, et al.
C.1-68-50	Comments on Hybrid Spectrometer Systems
A.3-68-91	Comments on Hybrid Visual-Magnetic Spectrometers
C.3-68-93	Further Comments on the Influence of Detector Spatial Resolution on Spectrometer Scaling
A.3-68-95	Comments on Substituting a Streamer Chamber for the Bubble Chamber in the Hybrid Bubble Chamber-Spark Chamber Detector Proposed by T. Fields et al. in NAL Summer Study Report A.3-68-12, June 29, 1968
C.3-68-98	Remarks on Doing Strong Interaction Physics Involving Multiparticle Final States in the 100 BeV Region
A.3-68-100	On the Use of a Hybrid Bubble Chamber in the 100 BeV Region

B. Other Papers

C.1-68-18	Spark Chamber Experiments: $\pi^- + p \rightarrow K^0 + \Lambda^0$ at 100 GeV
C.1-68-19	Hyperon Beams at 200 GeV Weston Accelerator and Possible Experiments with These Beams

B. Other Papers

C.4-68-57	Proposal for 12 Meter Streamer Chamber
C.1-68-10	The Electromagnetic Form Factor of the Charged Pion (Muon, Kaon, Electron)
C.1-68-11	An Experiment to Look at Backward Peaks in π-p Scattering
C.1-68-62	Spark Chamber Experiment on $\pi^- + p \rightarrow N^* + \rho^o$
C.4-68-64	A Few Thoughts about High Energy Detectors
C.3-68-65	Influence of Detector Spatial Resolution in the Scaling of NAL Experiments
C.1-68-69	Comments on C.1-68-10 by J. Poirier
C.1-68-70	Remarks on π-p Backward Scattering Experiments
C.2-68-99	A Spectrometer for Measuring Inelastic Secondaries from 200 GeV/c p-p Collisions